



The Horseshoe Falls—Illuminated by the Hydro-Electric Power Commission.

Hydro-Electric Power

in the

Niagara District

Province of Ontario

CANADA

Hydro-Electric Power Commission of Ontario

JULY, 1920



SEP 11 1931

POWER is essential to our modern existence. Without it we should be back in the Middle Ages, candles and torches for lighting; hand labor for all purposes; land transportation restricted to that provided by human and animal agencies and water transportation to small sailing ships dependent upon the vagaries of the wind; communication limited to the slow means of locomotion at the disposal of the courier, in the absence of anything faster than horses; these would form some of the conditions under which we should live.



*Col. Sir Adam Beck, Kt., LL.D.,
Chairman, Hydro-Electric Power
Commission of Ontario.*

Within the last two hundred years scientific discoveries have given to the world the power inherent in fuels, viz: coal, gas and oil, and in falling water, in the varied forms of heat, light, chemical action, mechanical power and electricity.

It has been estimated that the total water powers of the world available for

use amount to approximately 100,000,000 horsepower, of which only about 17,000,000 has so far been developed.

The Dominion of Canada possesses approximately 20 per cent. of the world's total water power, and also possesses approximately the same per cent. of the world's water power already developed. The people of the Province of Ontario are particularly concerned in the development of water power for two outstanding reasons:

(1) There is no coal within the Province and the manufacturers must depend upon the importation of coal from the far East or from the far West of the Dominion, or receive their coal supply from the United States.

(2) The Province contains an abundant supply of water power aggregating in all 6,000,000 horsepower, of which approximately 800,000 horsepower has already been developed.

The first of these resources to be utilized by man was coal, but although this fuel is very widely distributed, and exists in immense quantities in various parts of the earth, there is no denying the fact that the supply will some day come to an end.

The supplies of oil and gas, like those of coal, are limited in quantity, and if used in too prodigal a fashion will be exhausted all too soon.

Our remaining important source of energy, water power, differs from the fuels in one important respect, in that there is no need to fear that continued use will reduce the supply available for future generations; hence, one of the best means of conserving the fuel supplies is to substitute the use of water power wherever this is practicable. This is what the municipalities of Ontario have done for themselves in a very eminent degree, with extremely satisfactory results.

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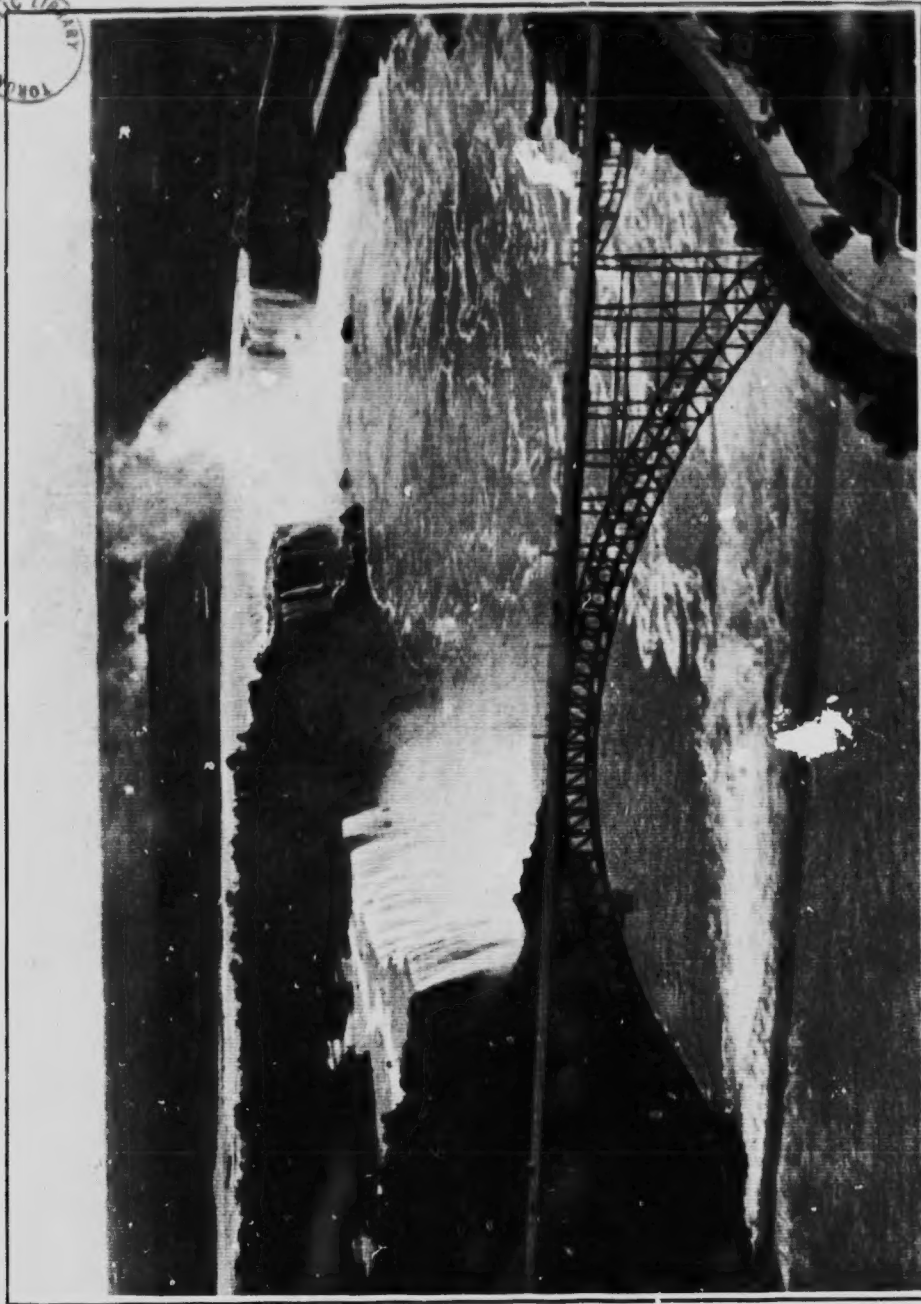
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Birdseye View of Niagara Falls.



THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

In 1907 the Provincial Legislature passed an Act known as the Power Commission Act, authorizing one or more municipalities in the Province, individually and jointly, through a Commission, to generate, transmit and deliver power. Under this legislation it was arranged that the cost of such work should be financed by loans of the Provincial

investigate the proposition of purchasing, generating and transmitting power from Niagara Falls to the municipalities in southwestern Ontario.

The Hydro-Electric Power Commission of Ontario is appointed by the Provincial Government to act as trustee and administrator for the municipalities which have signed contracts with the Commission for their power supply and become partners in the co-operative



An Ontario Farm supplied with Light and Power by the Hydro-Electric Power Commission.

Government, the loans to be secured by a lien on the property of the municipalities entering into the partnership scheme, due provision being made to return these loans at the end of thirty years. This action on the part of the Provincial Legislature was taken as the result of a favorable report submitted to the Legislature by the "Ontario Power Commission," appointed at an earlier date by the Provincial Government to

municipal scheme by which each municipality receives power at cost.

Each municipality having a contract with the Commission pays in its power bill not only the cost of power generated at the source of supply, but also a proportionate part of all interest charges, sinking fund charges, maintenance, renewals, and all other charges applicable to any business, on the expenditure necessary to transform and transmit the



Troop Train, London and Port Stanley Railway.



A Steel Trestle on the London and Port Stanley Railway.

power purchased or generated, from the source of supply to the point at which the power is used, the whole cost being adjusted so as to ensure the discharge of the entire indebtedness in thirty years.

Since its formation the growth of the Commission's activities has been enormous and from one system supplying approximately 4,000 horsepower to 12 municipalities in 1911, the work of the Commission has expanded so rapidly that at the present time the Commission has constructed, and is supplying power to, 11 different systems embracing over 250 municipalities to which are supplied approximately 340,000 horsepower distributed over an area nearly as large as that of England.

The following is a list of the Systems now being supplied by the Commission:

System	Approximate Present Load in Horsepower
Niagara	275,000
Severn	6,500
Eugenia	3,220
Wasdell's	400
St. Lawrence	2,000
Muskoka	1,500
Nipissing	1,300
Rideau	1,350
Ottawa	7,500
Central Ontario	33,000
Port Arthur	5,400

Total.....337,170 h.p.

Not only does the Commission supply power to urban municipalities but electric energy is now being furnished to over 500 farms located in various parts of the Province and to approximately 5,000 other rural consumers, and at the Commission's request the Provincial Government has recently passed legislation which will enable the Commission

to proceed with a large, comprehensive scheme to supply power to every rural district in Ontario.

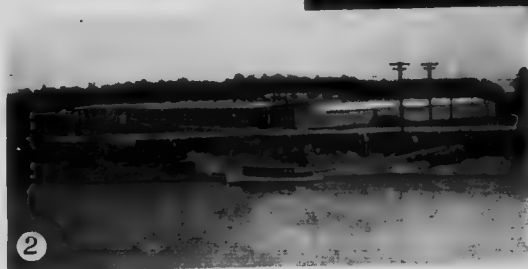
At the urgent request of municipalities throughout the Province, the Provincial Government passed an Act by which the Commission may purchase, construct and operate electric radial railways on behalf of the municipalities in a manner somewhat similar to that under which electric power is now supplied, and the Commission is now operating several electric railways and is negotiating for the purchase and construction of others.

NIAGARA DISTRICT

The term "Niagara District" includes the southwestern part of the Province of Ontario lying south of a line drawn between the town of Oshawa on Lake Ontario and the town of Goderich on Lake Huron; the area of this territory is about 11,950 square miles. Already the Commission has expended on behalf of the municipalities in this district approximately \$14,300,000, and the municipalities themselves have spent approximately \$20,000,000 in the construction of their own distribution systems.

Municipalities having contracts with the Commission receive power from the Commission *at cost* and the municipalities own and operate their own systems to distribute the power so supplied to power and lighting customers. The rates at which this power and light are supplied are, according to the "Power Commission Act," fixed by the Commission—these rates being adjusted annually to a cost basis, so that while each municipality owns and operates its own distribution system, it does so under the supervision and direction of the Commission.

The success of this co-operative scheme to date is best shown by results obtained which are set out in the following table for a number of the principal municipalities in this district:—



(1) Coniagas Reduction Co., Thorold. (2) Dain Manufacturing Co., Dainville. (3) American Cyanamid Co., Niagara Falls. (4) Union Carbide Co., Welland. (5) Page & Hersey, Welland.



(1) Electro Metals, Welland. (2) Canada Cement Co., Ltd., Port Colborne. (3) Ontario Paper Co., Thorold. (4) Dominion Foundries and Steel Co., Hamilton. (5) Canadian Yale & Towne, Ltd., St. Catharines.

PIONEER HYDRO MUNICIPALITIES

Municipality	Plant	Other Assets	Liabilities	Reserves	Surplus
Toronto	\$10,221,824.59	\$2,504,232.48	\$9,436,279.32	\$3,059,205.00	\$230,572.75
London	1,247,591.51	465,854.74	939,315.46	411,314.91	362,815.88
Guelph	265,060.70	128,081.34	127,731.62	127,805.73	137,604.69
Stratford	311,769.71	85,643.03	218,317.36	143,10.90	35,284.48
St. Thomas	263,284.76	81,607.28	106,361.92	103,862.67	134,667.45
Woodstock	192,958.89	117,455.39	126,086.57	99,460.43	84,867.28
Kitchener	444,935.20	91,340.95	225,684.68	194,794.64	115,796.83
Hespeler	36,999.09	13,282.58	1,962.47	24,504.75	6,814.45
Preston	123,128.81	32,165.84	69,411.37	57,504.35	28,378.93
Waterloo	117,535.70	28,983.24	60,242.89	45,332.98	40,943.07
New Hamburg	27,423.41	9,979.94	17,267.80	11,537.42	8,598.13
Ingersoll	108,309.90	63,587.79	86,605.69	40,460.93	44,831.07
	\$13,360,822.27	\$3,622,214.60	\$11,432,267.15	\$4,319,594.71	\$1,231,175.01

"Other Assets" includes Bank Balance, Security Investments, Accounts Receivable, Inventories, Sinking Fund Deposits and Operating Surplus.

The following is a statement showing the financial standing of the first 12 municipalities which went into co-partnership in order to obtain Hydro-Electric power for themselves in 1908.

Municipality	COST OF POWER, 1920.		AVERAGE RATE PER K.W.H. IN 1919.		
	To Municipality per H.P.	To Customer per H.P.	Domestic	Commercial	Old Rate.
Toronto	\$14.50	\$19.50	2.5c.	2.2c.	Dom. 8c. plus 25c. Comm. 12c. plus 25c.
Hamilton	14.00	12.70	2.3c.	1.3c.	Dom. 8c. plus 25c. Comm. 8c.
London	19.00	18.00	2.4c.	1.9c.	9c. plus 25c.
St. Thomas	24.00	18.00	2.9c.	1.9c.	11c.
Guelph	19.00	16.00	3.3c.	2.0c.	Dom. 8c. plus 25c. Comm. 8c. plus 15c.
St. Mary's	28.00	32.50	3.4c.	2.6c.	9c. plus 15c.
Waterloo	20.00	20.00	2.9c.	3.0c.	12c. plus 25c.
Hespeler	21.00	25.50	4.6c.	3.2c.	10c. plus 15c.
Windsor	36.00	35.00	3.9c.	3.0c.	Comm. 8c. Dom. 12c.
Sarnia	36.00	35.00	4.7c.	4.2c.	Dom. 6c. Comm. 5-4.
Stratford	25.00	28.00	2.6c.	2.7c.	Dom. 12c. plus 25c. Comm. 12c. plus 25c.
Woodstock	20.00	18.00	3.1c.	2.1c.	8c. plus 20c.
Preston	19.00	20.00	3.4c.	2.8c.	9c. plus 20c.
New Hamburg	32.00	31.00	5.5c.	3.8c.	10c.
Ingersoll	21.00	20.00	4.6c.	3.2c.	8c. plus 25c.

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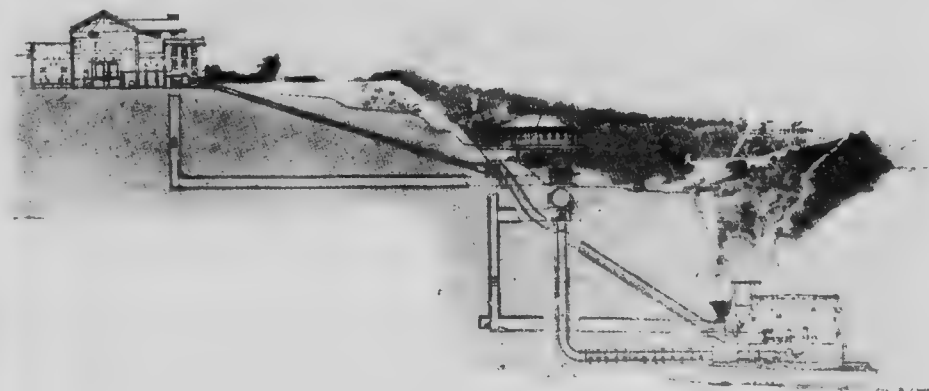


Generating Station, Overflow, Surge Tanks and Distributing Station of the Ontario Power Company, as seen from Goat Island.

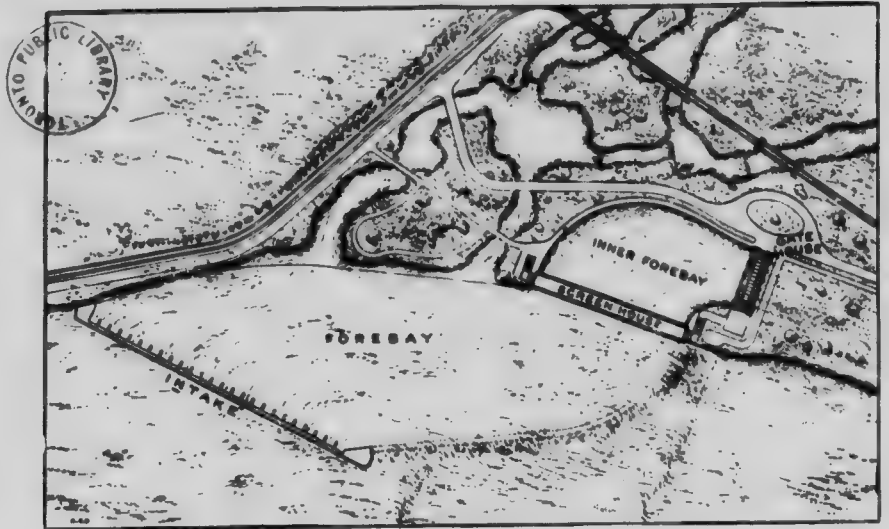
At the end of 1912 the combined load of these pioneer municipalities was 16,615 horsepower, now it is 90,799 horsepower. Eight of the twelve now have a surplus sufficient to cover their indebtedness to the Province. Considering the whole twelve jointly, the aggregate of reserves and surplus available is over five and a half million dollars as

against outstanding obligations totalling not quite eleven and a half millions.

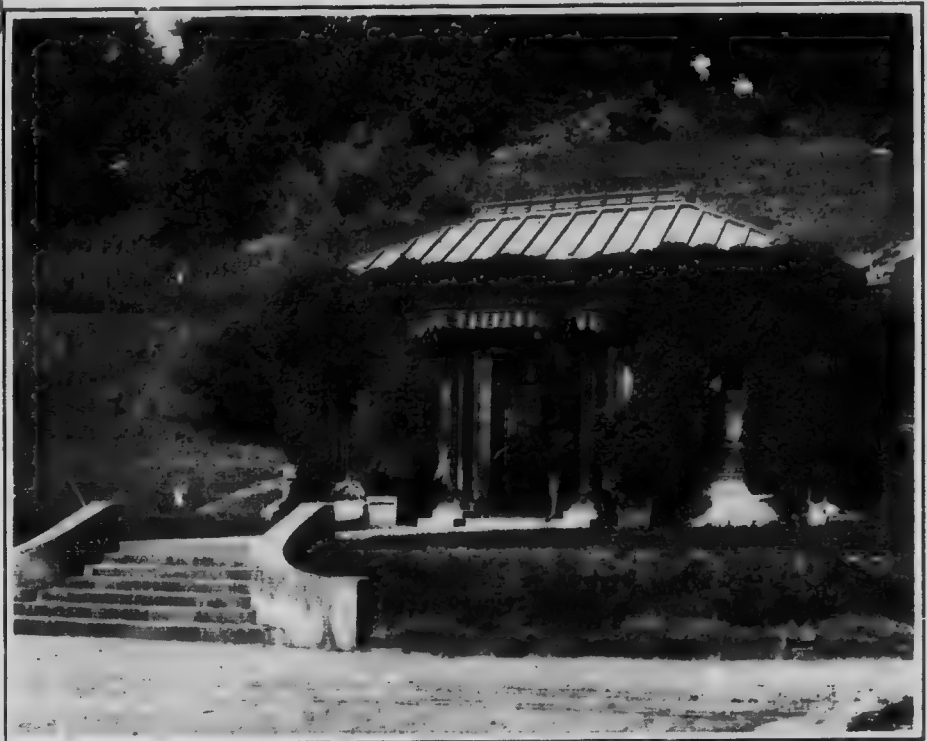
When the Commission first commenced operations in this District a contract for power was made with the Ontario Power Company for 100,000 horsepower at \$9.00 per horsepower per year. So rapid, however, was the growth of the demand in the district that in 1916 all



Section through Generating and Distributing Stations, Ontario Power Company.

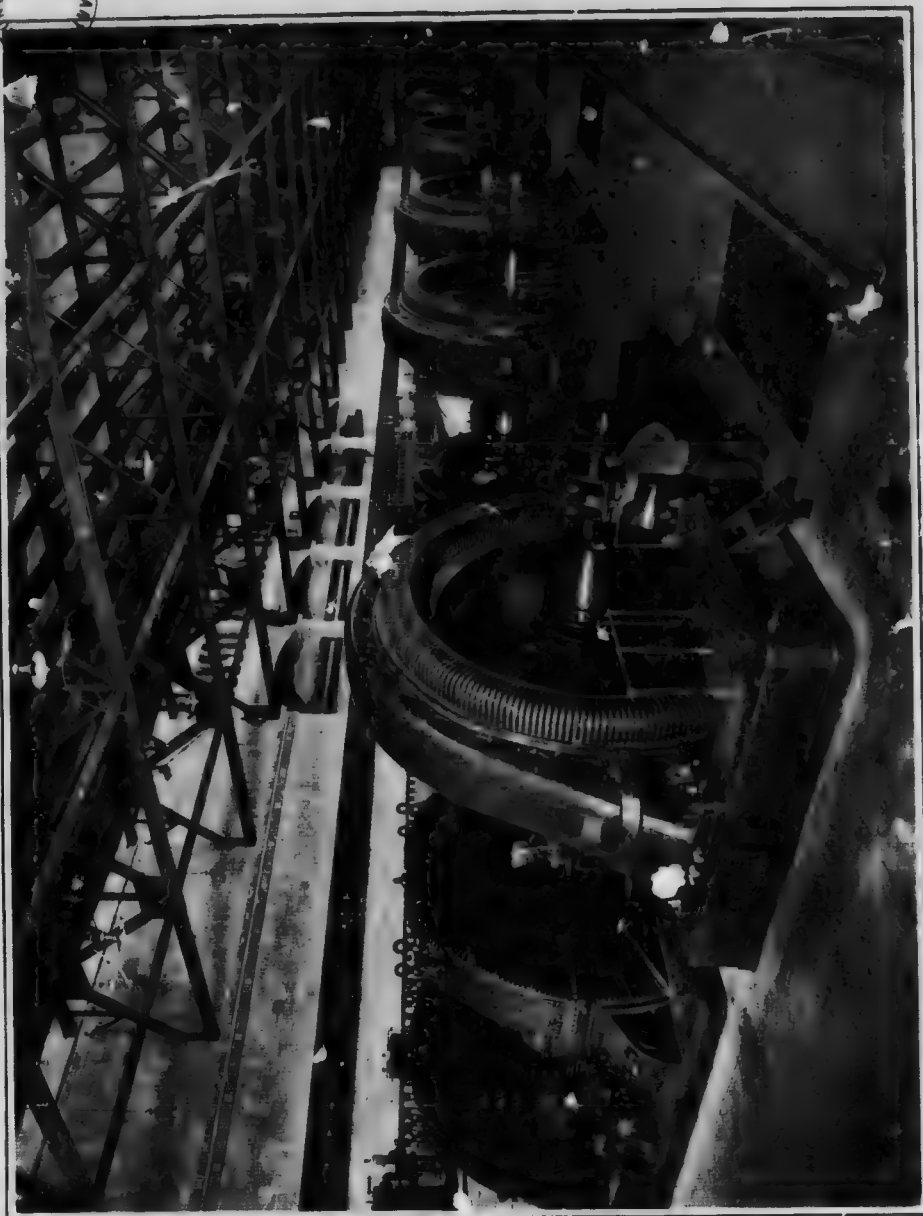


Plan of Intake Works, Ontario Power Company.



Entrance Building, Ontario Power Company.

TO PUBLIC LIBRARY



Interior of the Generating Station, Ontario Power Company.

of this power was used up and the Commission made another contract with the Canadian Niagara Power Company for an additional supply of 60,000 horsepower.

In 1917 the Commission purchased the entire plant of the Ontario Power Company, having at that time a total capacity of 162,000 horsepower, and in 1918, to meet the urgent demands for power for the manufacture of war munitions, an extension to this plant was made having a capacity of approximately 40,000 horsepower, so that this plant at the present time has a total capacity of approximately 200,000 horsepower.

The Commission has a contract with the Electrical Development Company for a supply of 13,200 horsepower, hence the Commission is now supplying from Niagara Falls a total of approximately 275,000 horsepower.

ONTARIO POWER COMPANY'S DEVELOPMENT.

Work on this scheme was commenced in 1902, and power was first supplied in 1905. In the year 1917 the Hydro-Electric Power Commission purchased the entire stock of the Company for \$8,000,000, and also assumed the debenture and bonded indebtedness of the Company for an additional amount of \$14,450,000. Since that time approximately \$3,500,000 has been spent to increase the capacity of the plant from 160,000 to 200,000 horsepower.

The head-works comprising intake, diverting dam, outer forebay, screen house, inner forebay and gate-house were all constructed suitably for the ultimate capacity of the development, viz.: 200,000 horsepower, but the other portions of the work were carried out more or less in stages keeping pace with the actual development. Thus, at the time



Wood Stave Pipe Line during Construction.

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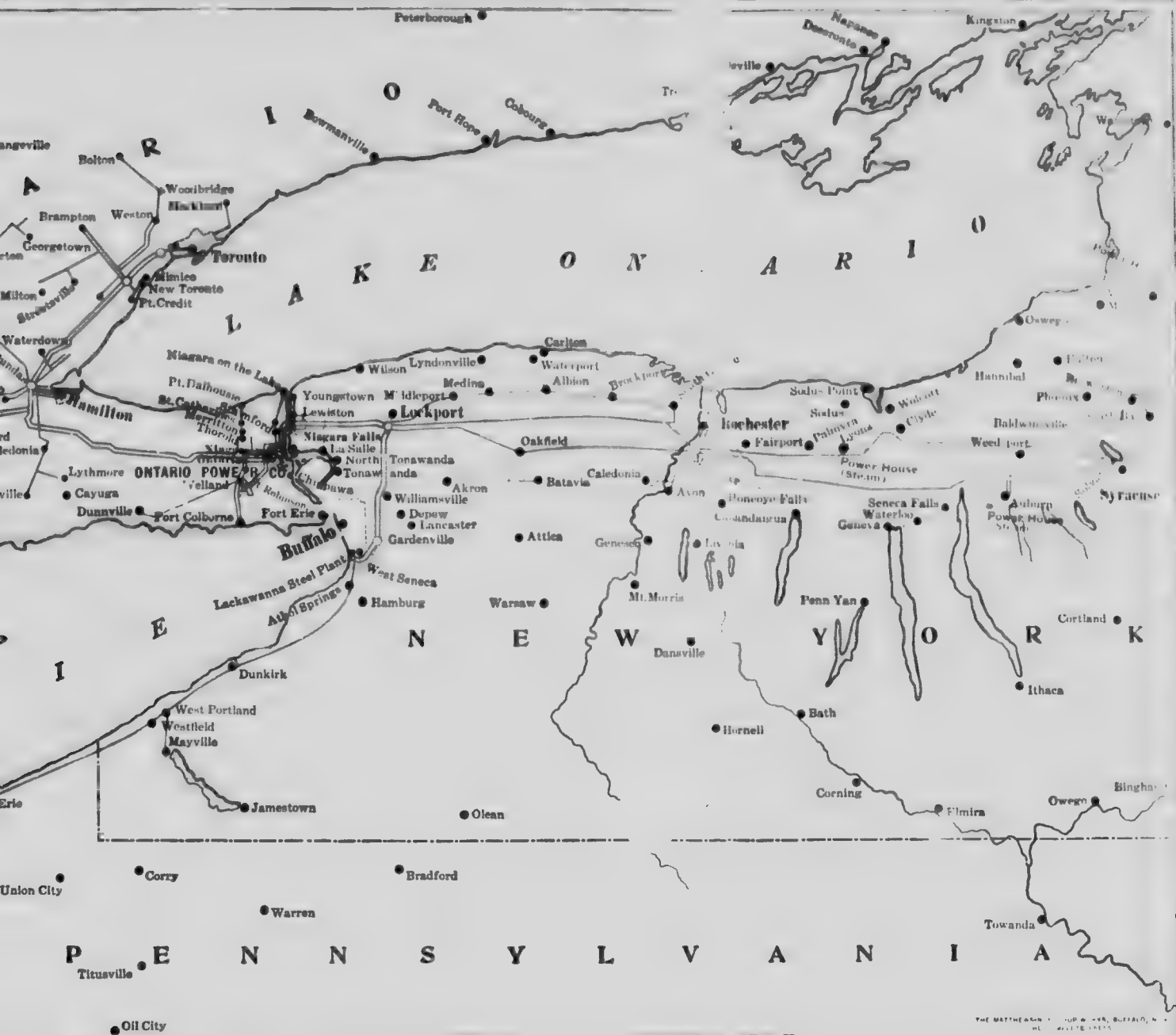


DISTRICT IN PROVINCE OF ONTARIO AND NEW YORK



NEW YORK STATE SUPPLIED WITH POWER FROM

NIAGARA FALLS



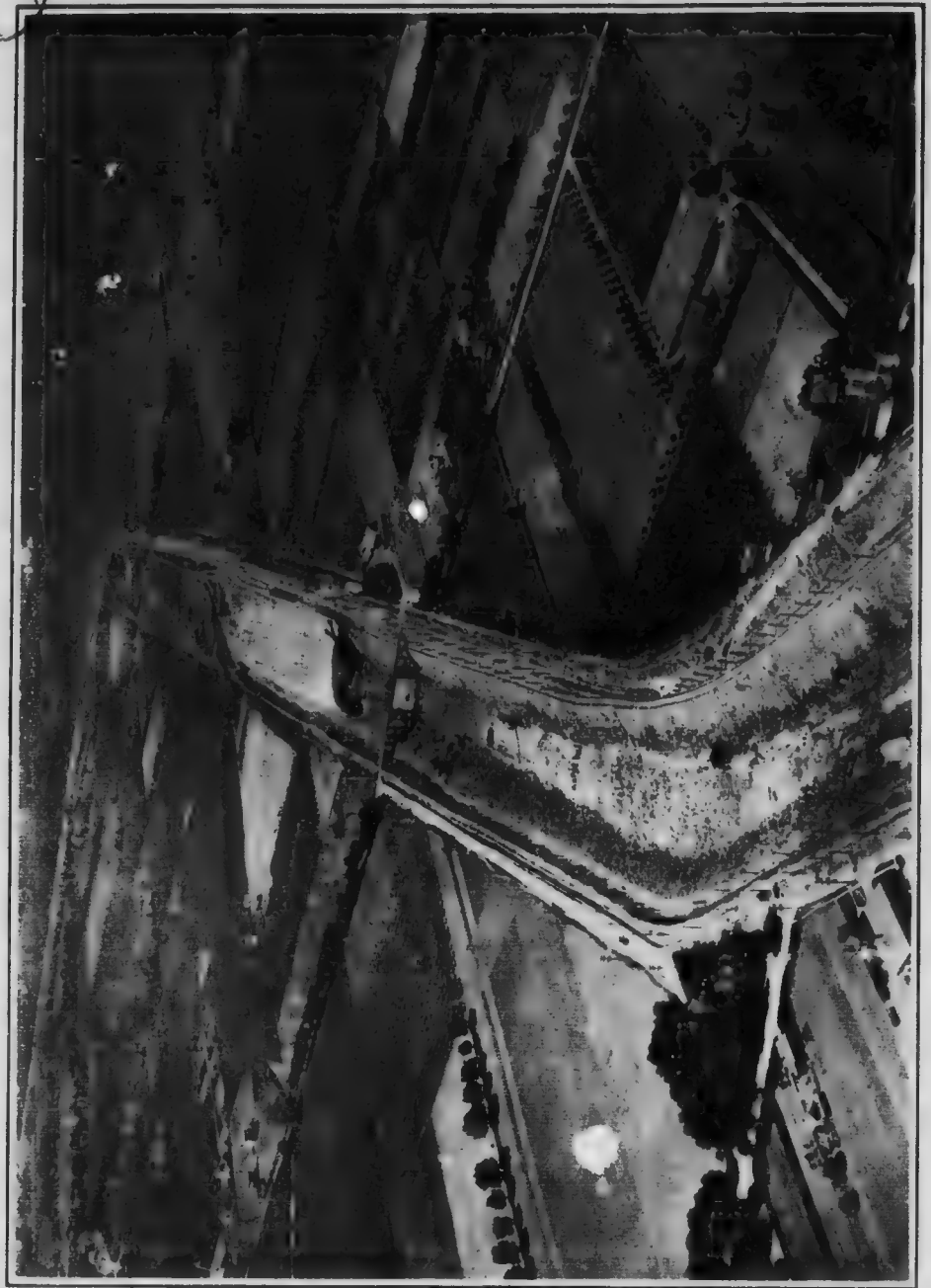
when the Commission took over the plant, there were only two 18-foot conduits installed to convey water from the head-works to the power house, and 14 horizontal turbines, each coupled to its own horizontal generator, with an aggregate capacity of 160,000 horsepower.

On account of the great demands for power during the war, the Commission

found it necessary, immediately after taking over this plant, to install a third conduit, which is a wood stave pipe line of 13½ feet internal diameter, together with two extra turbines and generators and auxiliary equipment, which increased the capacity of the entire plant to the present figure of 200,000 horsepower.



Birdseye View of Chippawa-Queenston Power Development.



Aeroplane view of the Power Canal, Chippawa-Queenston Power Development.

QUEENSTON-CHIPPAWA POWER DEVELOPMENT.

Realizing that the present available power supply in the Niagara District would be exhausted before 1920, the Commission in 1913 requested the Ontario Government to allow it to proceed with the construction of a large plant at Queenston. The legislation necessary in order that this work might be undertaken was not, however, obtained until 1917, when the great demand for power for the manufacture of war munitions entirely used up all of the available power supply at that time. In May, 1917, actual construction work on the Queenston-Chippawa development was commenced.

This great work involves the construction of a canal which will convey water

from the Upper Niagara River to a point near Queenston, where the largest power plant in the world will be located. This arrangement will permit of using the full available head of water between Lake Erie and Lake Ontario, which is more than twice the available head of the other power plants at Niagara Falls, thus delivering twice the amount of power from the same diversion of water.

Some of the outstanding features of the canal, the power house, and the equipment being used in their construction are as follows:

Canal

Length	12¾ miles.
Total excavation in earth.....	11 million cu. yds.
Total excavation in rock.....	4 million cu. yds.



Chippawa-Queenston Power Canal.

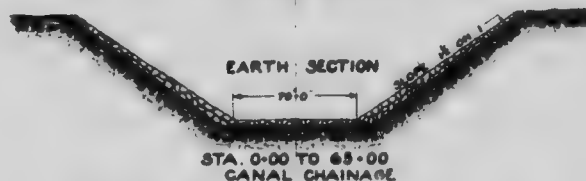
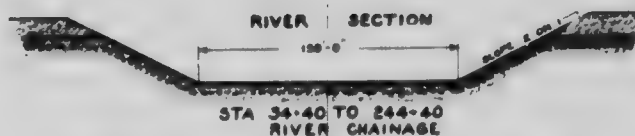




(1) Electric shovel operating in rock. (2) Electric shovel excavating earth and loading cars. (3) Power Canal, looking north from N. S. & T. Ry. bridge. (4) Power Canal from Bowman's Ravine. (5) Electric shovel at work (these shovels are the largest in the world). (6) View through the Power Canal from the floor of the Forebay.



(1) Cableway Excavator in Welland River. (2) Cableway excavator from East Bank of Welland River. (3) Site of the World's Largest Power House. (4) Drilling wall of Forebay. (5) Dredge loading a scow opposite Hog Island, at the mouth of the Welland River.



ROCK SECTION
STA. 65+00 TO 315+00
AND 366+00 TO 432+87

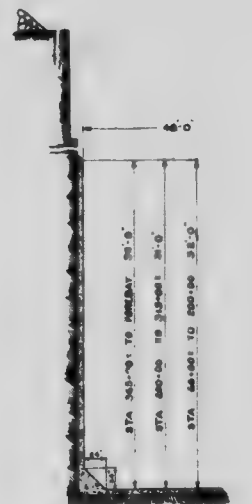
*Intake Loss and Velocity Head
in River Section* 0.500

Roughness Factor in River Section
 $n = .055$

Roughness Factor in Earth Section
 $n = .035$

*Roughness Factor in close-drilled rock
above concrete lining in Rock Section*
 $n = .033$

Roughness Factor in concrete lining
as shown



HALF SECTION
SHOWING CONCRETE LINING

This drawing supersedes 7-3-10'-8

Sections of the Power Canal.

The portion of the canal excavated in earth will have sloping sides, the width of the bottom being 70 feet, and at the top 162 feet; the average depth of the water will be about 30 feet. The rock portion of the canal will have vertical sides with a width of 48 feet and an average depth of water of 40 feet.

The net head of water utilized in this development will be 305 feet, and the capacity of the canal will be from 15,000 to 18,000 cubic feet per second.

Power House

The power house will contain the largest turbines and generators in the world, each of the former being of 55,000 horsepower capacity, coupled to an electric generator of equivalent size.

At the present time there are 5 of these immense units on order, two of which will be delivered this year.

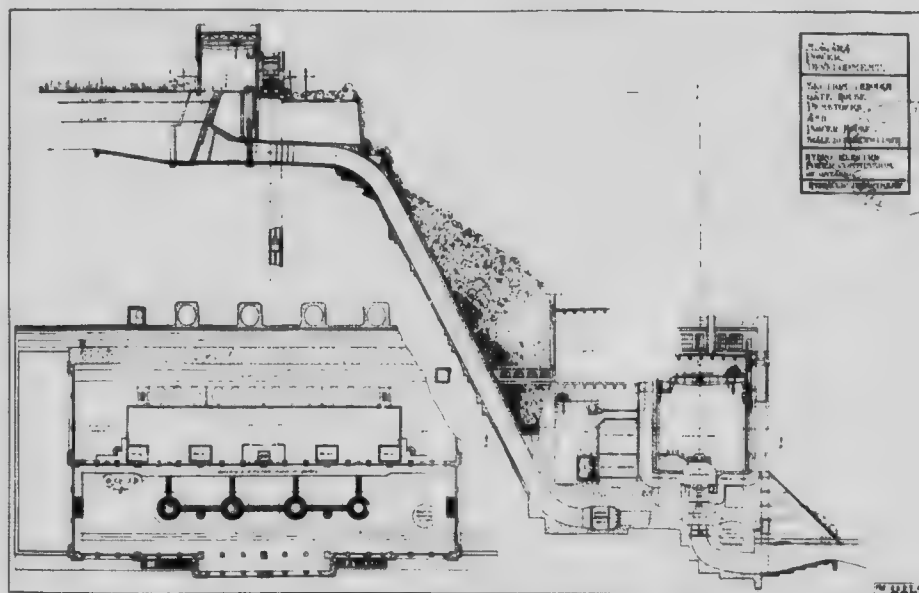
The entire project, up to an initial capacity of 100,000 horsepower will, it is expected, be completed in the Fall of

1921, and, about six months later three additional generating units will be installed, thus bringing the capacity up to 250,000 horsepower, and the ultimate capacity of the generating station will be from 500,000 to 600,000 horsepower.

Construction Equipment

Owing to the shortage and high cost of both labor and coal, it was decided to make the utmost use of labor-saving devices and electrically operated equipment is being used as much as possible.

For the work of excavating, there are in use 7 electrically operated shovels. Three of these are the largest in the world, being considerably larger than the shovels used in the construction of the Panama Canal; they handle an eight cubic yard bucket for earth, and a five cubic yard bucket for rock; motors aggregating no less than 750 horsepower are required to operate each; they weigh over 400 tons each, and have a capacity, when used for excavating earth, of



Section Through Gate House, Penstocks and Power House

150,000 cu' of yards per month per shovel and of 70,000 cubic yards when used for rock. These shovels can load cars standing 73 feet above their location.

Beside the electric shovels there are three steam shovels as well as 17 channelers and numerous rock drills, while for a $4\frac{1}{2}$ mile section of the canal, which will be formed out of a portion of the Welland River, a dredge and cable-way with a clam-shell excavator, are being employed.

In order to efficiently carry away the enormous amount of excavated material on this work, a standard gauge double track electric railway, in which standard 80-lb. main line rails have been used, has been constructed along the entire route of the canal, with a branch to the disposal area, where the excavated material is dumped. The rolling stock for this railway consists of 21 electric and 10 steam locomotives, besides 225 air dump cars of 20 cubic yards capacity each.

In order to expedite the work as much as possible a considerable amount of additional equipment has been ordered, including one 6 cubic yard Marion Steam Shovel, sixty-one air dump cars similar to those already in use; three more electric locomotives are being built and orders for two more are being contemplated.

Ten thousand electric horsepower is required to operate the electric railway, electric shovels and other machinery and equipment used on the construction work.

It will be necessary to build seventeen railway and highway bridges across the canal at various points.

The large amount of power obtained from this development will be sufficient to take care of the needs of the district for several years, and it is expected that this large supply of cheap power will result in even greater industrial development than that which has already taken place.

**POWER IS SUPPLIED TO MUNICIPALITIES
BY THE COMMISSION (AT COST)**

Power is supplied to Municipalities at cost, and monthly bills are submitted to the Municipalities for power supplied based on an estimated rate per horsepower per year, and, at the end of each year a Thirteenth Power Bill is submitted, debiting or crediting each Municipality with the difference between the amount already paid in monthly pay-

ments and the actual cost of service for the year.

The following is a typical Municipal Hydro Operating Report, and shows, in detail, the distribution of money collected from Hydro customers. This statement shows conclusively that Hydro Municipalities are required in their Power Bills to meet all Operating Expenses and Fixed Charges on their System, as well as to provide an adequate fund for renewals.

REVENUE obtained for Electric Service rendered, during the year ending

December 31, 1919

\$440,918.06

EXPENSES:

Paid by Local Utility to the Commission to meet the cost and transmission of Power as ascertained by Annual Adjustment--

Cost of Power at Niagara Falls.....	\$95,922.22
Interest on the Commission's Capital proportioned to the Municipality	31,025.99
Cost of Operating and Maintaining this share of Capital.....	32,815.87
Set aside to meet Contingencies and to provide a Renewal Fund for this share of Plant	18,182.69
A deposit to Sinking Fund to liquidate this share of Capital	12,887.73

Actual Cost of Power to Commission paid by Municipality.....

\$190,834.50

MUNICIPAL UTILITY'S EXPENSES

Sub-Station Operation	\$12,463.91
Sub-Station Maintenance	1,042.93
Distributing System Operation and Maintenance	5,183.29
Line Transformer Maintenance.....	4,187.89
Meter Maintenance	8,894.47
Consumers Premises Expenses	4,165.87
Street Lighting System Operation and Maintenance	8,312.31
Promotion of Business	6,951.65
Billing and Collecting	14,334.22
General Office Salary and Expenses	25,527.13
Undistributed Expenses	17,970.13
Interest and Debenture Payments	54,286.08
Provision on Account Plant Renewal	47,815.27

\$211,135.15

Total Cost of supplying Electric Service in this Municipality for one year.....	\$401,969.65
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SURPLUS	\$38,948.41
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HYDRO MUNICIPAL BALANCE SHEET 31st DECEMBER, 1919.

FIXED ASSETS

Lands and Buildings	\$1,709,288.61
Sub-Station Equipment	2,726,174.83
Distribution System, Overhead	6,131,871.17
Distribution System, Underground	1,082,037.59
Line Transformers	1,707,935.63
Meters	2,144,083.24
Street Lighting Equipment, Regular	1,064,380.08
Street Lighting Equipment, Ornamental	467,220.51
Miscellaneous Construction	2,319,093.73
Steam and Hydraulic Plant	97,903.59
Old Plant	539,846.21
Provincial Commission's Plant to serve Municipalities	14,098,318.19
	<u>\$34,088,153.38</u>

CURRENT ASSETS

Bank and Cash Balances	\$ 377,126.43
Securities and Investments	533,111.92
Accounts Receivable	997,777.64
Inventories	883,723.31
Other Assets	22,211.39
Sinking Fund on deposit with Municipal Treasurer	1,446,177.73
Sinking Fund on deposit with Provincial Commission	338,940.08
Over Payment to Provincial Commission in respect of Power Costs	496,972.18
Renewal Fund on deposit with Provincial Commission	1,508,875.94
	<u>\$6,604,916.62</u>

Total Assets	\$40,693,070.00
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LIABILITIES

Debenture Balance	\$15,161,106.66
Accounts Payable	899,823.49
Bank Overdraft	307,996.85
Other Liabilities	369,162.28
Underpayment to Provincial Commission in respect of Power Costs	114,357.33
Debenture debt in respect of Provincial Commission's Plant	14,098,318.19
	<u>\$30,950,764.80</u>

RESERVES

Debentures Paid	\$ 823,427.33
Sinking Fund Reserve	1,455,561.25
Sinking Fund Reserve in respect of Provincial Commission's Plant	338,940.06
Depreciation Reserve	3,145,035.66
Contingency Reserve	292,530.59
Renewal Reserve in respect of Provincial Com- mission's Plant	1,508,875.94
	\$7,564,370.83

SURPLUS \$2,177,934.37

\$9,742,305.00

The accounts of every Hydro-Electric Utility are kept in a uniform manner in conformity with the Accounting System published by the Commission. This code was prepared by a special committee of Chartered Accountants and Engineers and follows the general practice of public service corporations in the United States with such minor changes as were necessary to adapt it to a System financed by debentures rather than capital stock.

The Hydro Department balance sheets of all the Municipalities in the Niagara System as at December 31, 1919, have been combined into one, and is shown below. The municipal investment in plant is shown divided into its principal component parts and in the last line will be found the proportion of the Hydro-Electric Power Commission's System which they have assumed. The current assets are also set out in sufficient detail that further explanation is hardly necessary. The sinking fund deposited with the municipal treasurers is the provision

already made for the retirement of local sinking fund debentures, while the sinking fund with the Hydro Commission is the progress already made towards paying off the Commissions' investment above mentioned. The renewal fund is in respect to the Hydro Commission's System only and not the local distributing Systems, for which a provision of over Three Millions will be found among the Reserves. The local systems being largely financed with serial debentures calling for a payment on principal each year instead of a sinking fund; such payments have been charged direct to the Debenture Balance Account and properly appear among the Reserves as "Debentures Paid." Strictly speaking Debentures Paid, and the Sinking Fund Reserve for both local Systems and Provincial Commission's Plant may quite properly be considered as Surplus and added to the free Surplus, making a total Surplus from operation of nearly four million eight hundred thousand dollars.



LOCATION OF THE ONTARIO POWER CO. GENERATING STATION, PIPE LINES AND HEAD WORKS AT NIAGARA FALLS

